width and the index value, the other management table being prepared for each printing mode.

33. The method according to claim 32, wherein one of the printing modes is a mode for performing printing complementarily in accordance with a printing pass count.

REMARKS

Reconsideration and allowance of the subject application are respectfully solicited.

Claims 1-33 remain pending in the application, with Claims 1, 12 and 23 being independent.

Claims 1, 3, 7, 11, 12, 14, 18, 22-27 and 29-32 were rejected under 35 U.S.C. § 102 as being anticipated by U.S. Patent No. 5,497,174 (Stephany, et al.). Claims 2, 6, 13 and 17 were rejected under 35 U.S.C. § 103 as being unpatentable over Stephany, et al. in view of U.S. Patent No. 6,183,056 (Corrigan, et al.). Claims 4, 5, 10, 15, 16 and 21 were rejected under § 103 as being unpatentable over Stephany, et al. in view of European Patent Document No. 0 626 266 (Nagoshi, et al.). Claims 8 and 19 were rejected under § 103 as being unpatentable over Stephany, et al. in view of U.S. Patent No. 5,223,853 (Wysocki, et al.). Claims 9 and 20 were rejected under § 103 as being unpatentable over Stephany, et al. in view of U.S. Patent No. 5,289,207 (Ebisawa). Claims

28 and 33 were rejected under § 103 as being unpatentable over Stephany, et al. in view of U.S. Patent No. 5,610,638 (Courtney). These rejections are respectfully traversed.

Independent Claim 1 is directed to a printing apparatus for performing printing by using a printhead having a plurality of printing elements. Independent Claim 12 is directed to a method of controlling such a printing apparatus and independent Claim 23 is directed to a computer-readable memory storing program codes of control of such a printing apparatus. Each independent claim recites means for, steps of or program codes of discriminating the number of simultaneously driven printing elements of the plurality of printing elements when printing data is printed, determining a fundamental pulse width on the basis of driving conditions according to a condition of the printhead, and controlling a driving pulse to be applied to the printing elements used in the printing of the printing data, on the basis of the determined fundamental pulse width and the discriminated number of simultaneously driven printing elements.

In ink jet printing, a number of factors contribute to fluctuation of the ink discharge amount of the printhead. These factors including conditions of the printhead, such as unique characteristics of the printhead, the temperature of the printhead or the like. With the claimed arrangement and method, a fundamental pulse width is first determined on the basis of driving conditions according to a condition of the printhead. Because the driving pulse to be applied to the printing elements is controlled, inter alia, on the basis of such fundamental pulse width, the fundamental pulse width is determined before such controlling. After determining the fundamental pulse width, the drive pulse is controlled

based on the fundamental pulse width and a discriminated number of simultaneously driven printing elements.

Because the number of simultaneously driven printing elements changes in a short time period, that number can be a more important factor of the fluctuation of the ink discharge mount than the conditions of the printhead. Accordingly, fast pulse width modulation of the driving pulse is needed due to the rapid changes of the number of simultaneously driven printing elements. By determining in advance an optimal fundamental pulse width on the basis of the condition of the printhead, the only calculations needed immediately before controlling the driving pulse is discriminating the number of simultaneously driven printing elements. Accordingly, pulse width modulation can be performed in a short time in order to allow fast printing.

The ink jet printer of Stephany, et al. sets a driving pulse width by look-up tables contained in ROM1 46 on the basis of a two-bit word representing the number of heater elements to be fired as output from ROM2 44 according to simultaneously driven printing elements. Stephany, et al. further discloses setting a driving pulse width by look-up tables related to different types of ink. Accordingly, Applicants submit that Stephany, et al. discloses setting a driving pulse on the basis of printhead conditions such as the number of simultaneously driven printing elements, the different types of ink or the like, but does not disclose or suggest the above-noted features of the present invention. In particular, Stephany, et al. does not disclose or suggest determining a fundamental pulse width on the basis of driving conditions according to a condition of a printhead, and controlling a driving pulse to be applied to printing elements, on the basis of the

determined fundamental pulse width and a discriminated number of simultaneously driven printing elements, as is recited in independent Claims 1, 12 and 23.

Accordingly, Stephany, et al. fails to disclose or suggest important features of the present invention recited in the independent claims.

Corrigan, et al., Nagoshi, et al., Wysocki, et al., Ebisawa and Courtney have also been reviewed, but are not believed to remedy the deficiencies of Stephany, et al. noted above with respect to the independent claims.

Thus, independent Claims 1, 12 and 23 are believed to be patentable over the citations of record. Reconsideration and withdrawal of the §§ 102 and 103 rejections are respectfully requested.

For the foregoing reasons, Applicants respectfully submit that the present invention is patentably defined by independent Claims 1, 12 and 23. Dependent Claims 2-11, 13-22 and 24-33 are also allowable, in their own right, for defining features of the present invention in addition to those recited in their respective independent claims. Individual consideration of the dependent claims is requested.

This Amendment After Final Rejection does not raise new issues, is an earnest attempt to advance prosecution and reduce the number of issues, and is believed to clearly place this application in condition for allowance. This Amendment was not earlier presented because Applicants earnestly believed that the prior Amendment placed the subject application in condition for allowance. Accordingly, entry of this Amendment under 37 CFR 1.116 is respectfully requested.

Applicants submit that the present application is in condition for allowance. Favorable reconsideration, withdrawal of the rejections set forth in the above-noted Office Action, and an early Notice of Allowance are requested.

Applicants' undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should continue to be directed to our below-listed address.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE TO SPECIFICATION

The paragraph starting at page 1, line 18 has been amended as follows:

Printing apparatuses such as a printer, a copying machine, and a facsimile apparatus are so constructed as to print an image composed of dot patterns on a printing medium such as a paper sheet or thin plastic plate on the basis of image information. Printing apparatuses like this can be classified, [in accordance with printing systems] based on the type of printing system, into an inkjet system, a wire dot system, a thermal system, and a laser beam system. The inkjet system (inkjet printing apparatus) prints an image by discharging ink (printing solution) droplets from discharge orifices in a printhead and [landing] depositing the ink droplets on a printing medium.

The paragraph starting at page 2, line 4 has been amended as follows:

Recently, a large number of printing apparatuses [are] have been used, [and] wherein high-speed printing, high resolution, high image quality and low noise are required [for these printing apparatuses]. The above inkjet printing apparatus is an example of a printing apparatus meeting these requirements. This inkjet printing apparatus prints an image by discharging ink from a printhead, so [noncontacting] noncontact printing is possible. Hence, the inkjet printing apparatus can form stable printed images on a wide variety of printing media.

The paragraph starting at page 2, line 19 has been amended as follows:

[Unfortunately] However, an inkjet printing apparatus requires stable discharge of ink because the apparatus prints an image by discharging ink from a printhead. That is, the printhead of an inkjet printing apparatus must have stable performance with respect to durability, [environments] environment, [the] printhead temperature, [the] number of simultaneously discharged ink droplets, and the like.

The paragraph starting at page 7, line 1 has been amended as follows:

A printing apparatus according to the present invention, for achieving the above object, has the following arrangement.

The paragraph starting at page 7, line 4 has been amended as follows:

A printing apparatus for performing printing by using a printhead having a plurality of printing elements comprises discriminating means for discriminating the number of simultaneously driven printing elements of the plurality of printing elements when printing data is printed, and control means for controlling a driving pulse to be applied to printing elements used in the printing of the printing data, on the basis of a fundamental pulse width [changeably]. The fundamental pulse width is variable and is

determined on the basis of driving conditions of the printhead and the number of simultaneously driven printing elements discriminated by the discriminating means.

The paragraph starting at page 7, line 21 has been amended as follows:

Preferably, the control means comprises storage means for storing a first management table for managing the correspondence of the driving conditions with the fundamental pulse width, and a second management table for managing the correspondence of the fundamental pulse width with a change amount of the fundamental pulse width based on the number of simultaneously driven printing elements[,]; first determining means for determining a fundamental pulse width corresponding to the driving conditions by [looking up] referring to the first management table[,]; and second determining means for determining a change amount of the fundamental pulse width, which corresponds to the number of simultaneously driven printing elements, by [looking up] referring to the second management table, and changes the fundamental pulse width determined by the first determining means by the change amount determined by the second determining means to generate a driving pulse to be applied to printing elements used in the printing of the printing data.

The paragraph starting at page 8, line 21 has been amended as follows:

Preferably, the control means comprises storage means for storing a third management table for managing the correspondence of rise time and fall time of the heat pulse, the driving conditions, and the fundamental pulse width, and controls a pulse width of the driving pulse corresponding to the number of simultaneously driven printing elements and the driving conditions by [looking up] referring to the third management table.

The paragraph starting at page 10, line 3 has been amended as follows:

Preferably, if the number of simultaneously driven printing elements for use in predischarge of the printhead is limited, the control means makes a pulse width of a driving pulse [to be] applied to printing elements used in the predischarge larger than a pulse width of a driving pulse [to be] applied to printing elements for use in printing, which uses an equal or larger number of printing elements [equal or larger in number to or] than the number of simultaneously driven printing elements used in predischarge.

The paragraph starting at page 11, line 25 has been amended as follows:

A computer-readable memory storing program codes [of] for control of a printing apparatus for performing printing by using a printhead having a plurality of printing elements comprises a program code of the discrimination step of discriminating the number of simultaneously driven printing elements of the plurality of printing elements

when printing data is printed, and a program code of the control step of controlling a driving pulse to be applied to the printing elements used in the printing of the printing data, on the basis of the number of simultaneously driven printing elements discriminated in the discrimination step and a fundamental pulse width determined on the basis of driving conditions of the printhead.

The paragraph starting at page 30, line 3 has been amended as follows:

The power supply unit E0015 supplies head power (VH) E1039, [the] motor power (VM) E1040, and logic power (VDD) E1041. A head power ON signal (VHON) E1022 and a motor power ON signal (VMOM) E1023 from the ASIC E1006 are input to the power supply unit E0015 to control ON/OFF of the head power E1039 and the motor power E1040, respectively. The logic power (VDD) E1041 supplied from the power supply unit E0015 is subjected to voltage transformation where necessary and supplied to individual units inside and outside the main PCB E0014.

The paragraph starting at page 41, line 24 has been amended as follows:

Common ink discharge is performed by ANDing printing data and a heat pulse. Printing data determines the presence/absence of printing. A heat pulse involves [in] <u>the</u> control of discharge energy. Also, driving all dischargeable nozzles at the same

time excessively increases the required electric power, generated heat amount, and ink supply amount. Therefore, discharge nozzles are usually separately driven.

The paragraph starting at page 49, line 19 has been amended as follows:

In step S101, a heater rank and TrON rank serving as the printhead characteristics, and environmental temperature are detected. In step S102, on the basis of the detected heater rank, TrON rank, and environmental temperature, a driving pulse No. is determined by [looking up] referring to the table shown in Fig. 18. In step S103, a fundamental pulse width corresponding to the determined driving pulse No. is determined by [looking up] referring to the table shown in Fig. 19. In step S104, the number of simultaneous ink discharging nozzles of the printhead to be processed is discriminated. In step S105, a modulation amount of the fundamental pulse width, which corresponds to the discriminated number of simultaneous ink discharging nozzles, is determined by [looking up] referring to the table shown in Fig. 20, and the fundamental pulse width is modulated by this modulation amount to generate a driving pulse.

The paragraph starting at page 50, line 9 has been amended as follows:

Note that the above processing is realized by the aforementioned main PCB (E0014) shown in Fig. 8 by controlling the individual components shown in Fig. 21 by [looking up] referring to the driving pulse width tables shown in Figs. 18 to 20.

The paragraph starting at page 51, line 4 has been amended as follows:

In the first embodiment, to improve both the discharge stability and the heater durability, a reduction in the input energy to the heater caused by the voltage drop [by] due to the number of simultaneous ink discharging nozzles is compensated for by the pulse width. However, this first embodiment is similarly applicable to a case in which a short pulse for holding the temperature, not for discharging ink, is input.

The paragraph starting at page 51, line 25 has been amended as follows:

In this apparatus, three numbers of simultaneous ink discharging nozzles exist: the number S1 of simultaneous ink discharging nozzles for a printhead 2002, the number S2 of simultaneous ink discharging nozzles for a printhead 2003, and the total number S3 (=S1 + S2) of simultaneous ink discharging nozzles. [Strictly] Particularly, a voltage drop with respect to the printhead 2002 is affected by the resistances of C-11 and C-12, the number S1 of simultaneous ink discharging nozzles, the resistance of a current smoothing portion, and the total number S3 of simultaneous ink discharging nozzles. Driving pulse width control taking account of all these factors is complicated. Therefore, the resistance value of the current smoothing portion is designed to be low, and the number of simultaneous ink discharging nozzles of each power supply system is counted assuming that the degree of a voltage drop (by the resistances of C-11 and C-12 and the number S1 of simultaneous ink discharging nozzles) primarily caused by a pulse current is large. In

this manner, a driving pulse width for compensating for voltage drops in the lines C-11 and C-12 caused by simultaneous discharge is determined. If the two power supply systems are different in, e.g., [the] head driving voltage, [the] number of nozzles, [the] discharge amount, or [the] driving pulse width, preparing different driving pulse width tables for these systems makes the present invention adaptable.

The paragraph starting at page 53, line 19 has been amended as follows:

The average number of simultaneous ink discharging nozzles presumably has a certain upper limit when limitations on an ink [implantation] deposition amount with respect to a printing medium or division of a printing pass is taken into consideration. That is, although the number of simultaneous ink discharging nozzles [exceeding] may exceed this upper limit [is possible] in [a] certain [instant] instances, the average number of simultaneous ink discharging nozzles is not so large. Hence, voltage drops are suppressed to be low by capacitor components, and driving is performed by an excess driving pulse width.

The paragraph starting at page 55, line 22 has been amended as follows:

When the voltage drop changes depending on the number of simultaneous ink discharging nozzles for each printing mode such as the number of passes or the number of colors used, the optimal driving pulse width must preferably be changed for each

printing mode. In the table system (Fig. 20) for setting the pulse width itself for pulse width correction for compensating for the voltage drop by the number of simultaneous ink discharging nozzles for the driving pulse No. determined by the heater rank and TrON rank of the printhead and the environmental temperature, the table shown in Fig. 20 must be prepared for each printing mode to increase the table capacity. In Fig. 20, the number of driving pulses is 16, and the number of ranks of the number of simultaneous ink discharging nozzles is 4. If the number of printhead chips increases to increase the number of simultaneous ink discharging nozzles, this increases the number of ranks of the simultaneous ink discharging nozzles. The capacity of the table for each printing mode inevitably increases. To solve this problem, the table configuration in Fig. 27 is employed in place of the table [contents] configuration in Fig. 20 in which the pulse width is directly designated. The table in Fig. 27 stores [the] each simultaneous ink discharging pulse No. in the form of an index No. representing the table contents as a combination of the driving pulse No. and the number of simultaneous ink discharging nozzles. In addition, another table is prepared to store the relationship between the simultaneous ink discharging pulse No. and the P2 set value for setting the fall time of the pulse width. More specifically, only one table (Fig. 27) representing the driving pulse No. and the number of simultaneous ink discharge nozzles is prepared, while the table (Fig. 38) representing the relationship between the [number of] simultaneous ink discharging pulse No. and the P2 set value is prepared for each printing mode. The optimal pulse width can be set for each printing mode without increasing the table capacity. In this case, since the simultaneous ink discharging pulse No. is merely an index No. for determining the P2 set value, the

correlation between the No. value and the pulse width is not always required. All "0"s are assigned to the discharge range of 0 to 7 as the number of simultaneous ink discharge nozzles for the driving pulse Nos. 1 to 4 in Fig. 2-7. Assume that the same pulse width must be set in a printing mode A, and that different pulse widths must be set for the driving pulse Nos. 1 and 2 and the driving pulse Nos. 3 and 4 in a printing mode B. Using a driving pulse No. and a simultaneous ink discharging pulse No. (No. 20 in this case) not used in the table of simultaneous ink discharging pulse Nos., a table having the contents shown in Fig. 39 is prepared. The table representing the relationship between the simultaneous ink discharging pulse No. and the P2 set value for each mode is replaced with a table shown in Fig. 40, thereby allowing optimal control for each printing mode without increasing the table [content as much as possible] contents any more than necessary.

The paragraph starting at page 59, line 19 has been amended as follows:

As a representative arrangement or principle, it is preferable to use the basic principle disclosed in, e.g., U.S.[P.] Patent No. [4723129] 4,723,129 or [4740796] 4,740,796. This system is applicable to both a so-called on-demand apparatus and continuous apparatus. The system is particularly effective in an on-demand apparatus because at least one driving signal which corresponds to printing information and which gives a rapid temperature rise exceeding [nuclear] nucleate boiling is applied to an electrothermal transducer which corresponds to a sheet or channel holding a liquid (ink), thereby causing this electrothermal transducer to generate thermal energy and cause film

boiling on the thermal action surface of a printhead, and consequently a bubble can be formed in the liquid (ink) in one-to-one correspondence with the driving signal. By growth and shrinkage of this bubble, the liquid (ink) is discharged from a discharge orifice to form at least one droplet. This driving signal is more preferably a pulse signal because growth and shrinkage of a bubble are instantaneously appropriately performed, so discharge of the liquid (ink) having high response is achieved.

The paragraph starting at page 60, line 15 has been amended as follows:

This pulse driving signal is preferably a signal described in U.S.[P.] Patent No. [4463359] 4,463,359 or [4345262] 4,345,262. Note that superior printing can be performed by the use of conditions described in U.S.[P.] Patent No. [4313124] 4,313,124 which is the invention concerning the rate of temperature rise on the thermal action surface.

The paragraph starting at page 60, line 21 has been amended as follows:

The arrangement of a printhead can be the combination (a linear liquid channel or a right-angle liquid channel) of the discharge orifices, liquid channels, and electrothermal transducers disclosed in the specifications described above. The present invention also includes arrangements using U.S.[P.] Patent Nos. [4558333] 4,558,333 and [4459600] 4,459,600 in each of which the thermal action surface is placed in a bent region.

Additionally, it is possible to use an arrangement based on Japanese Patent Laid-Open No. 59-123670 in which a common slot is used as a discharge portion of a plurality of electrothermal transducers or Japanese Patent Laid-Open No. 59-138461 in which an opening for absorbing the pressure wave of thermal energy is opposed to a discharge portion.

The paragraph starting at page 62, line 9 has been amended as follows:

A recording mode of the printing apparatus is not restricted to a printing mode using only a main color such as black. That is, the apparatus can have [at least] a composite color mode using different colors and a full color mode using mixed colors, regardless of whether a printhead is an integrated head or the combination of a plurality of heads.

The paragraph starting at page 63, line 1 has been amended as follows:

Additionally, to positively prevent a temperature rise [by] due to thermal energy, by positively using this temperature rise as energy of the state change from the solid state to the liquid state of ink, or to prevent evaporation of ink, ink which solidifies when left to stand and liquefies when heated can be used. That is, the present invention is applicable to any ink which liquefies only when thermal energy is applied, such as ink which liquefies when applied with thermal energy corresponding to a printing signal and is

discharged as liquid ink, or ink which already starts to solidify when arriving at a printing medium. As described in Japanese Patent Laid-Open No. 54-56847 or 60-71260, this type of ink can be held as a liquid or solid in a recess or [through hole] through-hole in a porous sheet and opposed to an electrothermal transducer in this state. In the present invention, executing the aforementioned film boiling scheme is most effective for each ink described above.

The paragraph starting at page 64, line 6 has been amended as follows:

Further, the object of the present invention can also be achieved by providing a storage medium storing program codes of software for performing the aforesaid functions, according to the embodiments, in [to] a system or an apparatus, reading the program codes with a computer (or a CPU or MPU) of the system or apparatus from the storage medium, and then executing the program codes.

The paragraph starting at page 64, line 22 has been amended as follows:

Furthermore, besides the aforesaid functions according to the above embodiments [are] being realized by executing the program codes which are read out by a computer, the present invention also includes a case where an OS (Operating System) or the like running on the computer performs all or a part [or the whole] of actual [processing]

processings in accordance with designations by the program codes and realizes the functions according to the above embodiments.

The paragraph starting at page 65, line 18 has been amended as follows:

As [many apparently widely] a wide variety of different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.

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